Solar Cells, Inc.

Technology Partner

US DOE NREL THIN FILM PV PARTNERSHIP

Background

In 1989, Solar Cells, Inc. (SCI), of Toledo, Ohio, began work on CdTe thin-film photovoltaic (PV) material. It competed in a National Renewable Energy Laboratory (NREL) thin-film research procurement and won an award for about $300,000 per year for 3 years. During that period, SCI made major progress in developing a new, low-cost method of depositing thin-film materials. In parallel, SCI used its process (a form of high-rate evaporation) to make very large thin-film modules (about 0.72-m^2). The size of these modules, and their efficiencies attained, now rival or surpass anything comparable in thin-film products. The rate at which they are made (all the active layers in about 1 minute) is also unsurpassed and has important implications for reaching low costs.

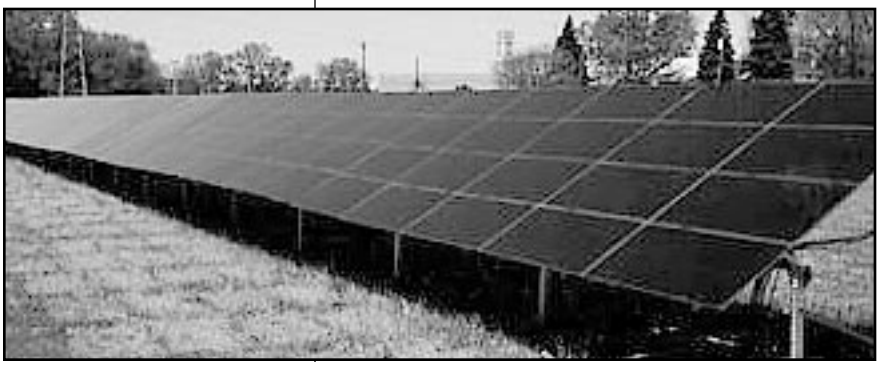

Figure 1. SCI has deployed a 10-kW array feeding electricity into the Toledo Edison grid in order to test outdoor reliability (Toledo, Ohio).

In 1992, SCI started a follow-on 3-year research subcontract with NREL for $600,000 annually. During this contract, SCI fabricated submodules of nearly 9% efficiency.

In 1994, SCI won a competition for a cost-shared research contract as a technology partner within the Thin-Film Partnership Program. SCI is receiving 3 years of funding at $1 million per year from the U.S. Department of Energy (DOE)/NREL while contributing about 20% cost sharing. SCI participates with other awardees on the CdTe National Research and Development (R&D) Team.

Since the contract's inception, SCI has deployed its first 10-kilowatt (kW) grid-connected array (Figure 1) and announced plans for a large (30-megawatt [MW]/year) thin-film production facility. SCI's progress from start-up to precommercial technological success was achieved with the support of the DOE/NREL Thin-Film Program.

NREL's partnership with SCI is more the rule than the exception in NREL's DOE-sponsored PV Program. Through NREL-managed, competitive, cost-shared R&D subcontracts, NREL has partnered with leaders in PV on the assumption that they will lead the way toward true commercial success. At the same time, NREL's in-house researchers have played a facilitating role, supporting near-term corporate progress while identifying and addressing key longer-term research problems.

Technical Highlights

To make a new, viable PV product, SCI has addressed numerous key technical issues: (1) improving PV cell efficiencies, (2) perfecting high-rate, high-yield film fabrication and processing techniques, (3) studying the interaction of module encapsulation with existing film layers, (4) ensuring process quality control, and (5) testing outdoor reliability. Cell and module efficiencies, yields, process rates, and materials utilization rates have steadily improved, as has performance in outdoor and accelerated tests. Figure 2 shows a 0.72-m^2 prototype module measured in 1996 at an aperture-area efficiency of better than 9.1%, making it the best thin-film module of that size. Figure 3 shows the high-rate deposition equipment in SCI's production facility. Figure 4 shows the results of a 1-kW SCI array being tested outdoors at NREL for stability.

During 1995, SCI and NREL's in-house researchers successfully worked together on cell-contacting technology and on an in situ quality control technique. This collaboration allows SCI to retain the rights to results from the cooperative work.

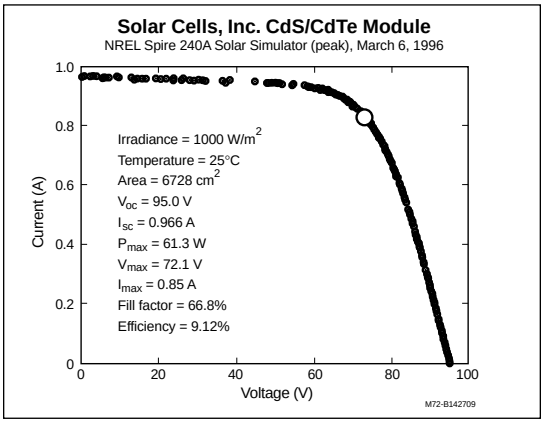

Figure 2. NREL has measured a SCI module at 9.1% efficiency (total-area basis). This module produced the most output (>60 W_p) of any thin-film module ever measured.

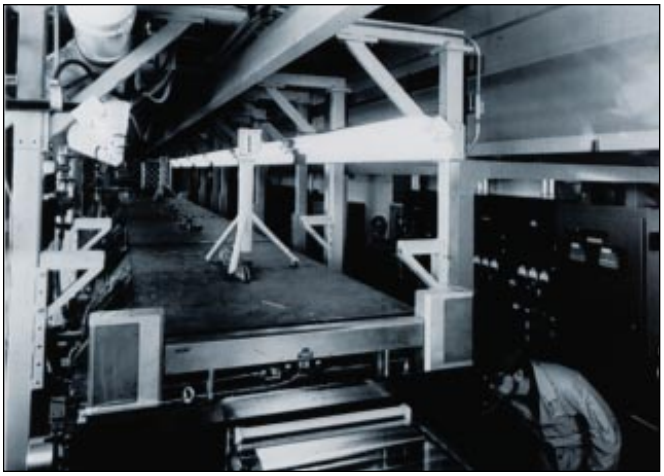

Figure 3. SCI uses a high-rate vapor transport process to make the critical semiconductor layers. It deposits the thin films in less than 1 minute, the fastest rates in the PV industry.

Future Plans

Mike Cicak, president of SCI, says, "Our progress and even our existence as a viable PV company have depended on the partnership that we have shared with DOE/NREL to develop thin-film modules." DOE/NREL and SCI look forward to continued shared efforts to develop the SCI thin-film technology. The Thin-Film Partnership assists SCI in two important ways: by helping it address key technical problems as it moves through the pilot production phase, and by working with SCI (and through the CdTe National Teams) to maintain a high level of future progress by continued, technical development of improved "next generation" products.

SCI is building a thin-film production capability. Depending on market factors, SCI could move to high-volume production during 1997–1998. SCI has an existing contract with Toledo Edison (Toledo, Ohio), a subsidiary of Centerior Energy, to whom it has already delivered 100 kW of PV. SCI has installed a 1-kW array in Tunisia (northern Africa) for testing and plans to deliver another 100-kW array. SCI has also installed a 10.8-kW array at PVUSA and a 25-kW array at Edwards Air Force Base, California.

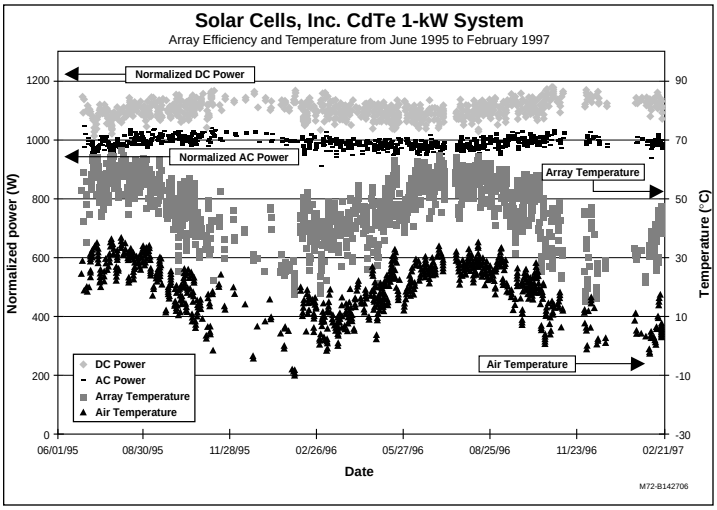

Figure 4. Solar Cells, Inc., installed a 1-kW system at NREL, and it has shown excellent stability over a 20-month period.

SCI has given NREL summary cost estimates that illustrate the attractiveness of its technology. SCI anticipates that the unique combination of its CdTe technology and high-throughput operational process will enable it to achieve a low-cost position within the industry. To illustrate, the analysis shown in Table 1 is a breakdown of cost segments based on 10% conversion efficiency for a 10-MW plant, extrapolated from SCI's current pilot production process.

Category	$/W
Direct Material	0.41
Direct Labor	0.11
Operating Costs	0.08
Equipment Depreciation	0.06
Other Cost Factors	0.10
Total Cost of Goods Sold	0.76

Table 1

SCI anticipates achieving conversion efficiencies greater than 10%, a confident forecast based on research results to date. Innovative technologic refinements and operational throughput benefits will continue to reduce these costs significantly, to less than $0.50/W. The company forecasts that this low-cost position will enable it to serve various high-volume segments of the utility market at $0.05–$0.10/kWh, depending on specific geography and financing.

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